

***Fiscal Year 2003
Environmental Monitoring
Report for the Radioactive
Waste Management Complex***

*L. Don Koeppen
Alva M. Parsons
A. Jeffrey Sondrup
Paul D. Ritter
Gail L. Olson*

**Idaho
Completion
Project**

Bechtel BWXT Idaho, LLC

April 2004

ICP/EXT-04-00259
Revision 1
Project No. 023378

Fiscal Year 2003 Environmental Monitoring Report for the Radioactive Waste Management Complex

**L. Don Koeppen
Alva M. Parsons
A. Jeffrey Sondrup
Paul D. Ritter
Gail L. Olson**

April 2004

**Idaho Completion Project
Idaho Falls, Idaho 83415**

**Prepared for the
U.S. Department of Energy
Assistant Secretary for Environmental Management
Under DOE Idaho Operations Office
Contract DE-AC07-99ID13727**

ABSTRACT

This report summarizes data resulting from monitoring the air, waste zone, vadose zone, and aquifer in and around the Radioactive Waste Management Complex within the Idaho National Engineering and Environmental Laboratory. This report is a joint publication of the Clean/Close Radioactive Waste Management Complex Project and the Landfills and Waste Disposal Project, and the results summarized here are used to satisfy several requirements and needs. The Landfills and Waste Disposal Project uses the results to comply with requirements of U.S. Department of Energy Order 435.1, "Radioactive Waste Management," Chapter IV, and the associated implementation manual and guidance, which require monitoring of low-level radioactive waste disposal facilities. The Clean/Close Radioactive Waste Management Complex Project uses the monitoring results to support activities associated with the ongoing Comprehensive Environmental Response, Compensation, and Liability Act risk assessment for Waste Area Group 7, which comprises the Radioactive Waste Management Complex.

Data from Fiscal Year 2003 are presented in detail, and historical aquifer data from Fiscal Years 1997–2003 are summarized to facilitate evaluation of temporal and spatial trends. Organic contaminants are shown to be declining in the soil gas because of ongoing vapor-vacuum extraction efforts in the vadose zone. Anion, cation, and metal contaminants are widespread in the vadose zone and are mostly attributable to magnesium chloride brine applied to roads within the Subsurface Disposal Area many years ago as a dust suppressant. Nitrate is not associated with the brine; it has relatively high and increasing concentrations that could provide data for model calibration. Radionuclide detections are evaluated over time and within the context of disposals to determine whether there are any candidate nuclides for model calibration efforts. Technetium-99, C-14, and H-3 are detected regularly at one or more locations, but the detections do not correlate well with the disposal locations. Trends in uranium detections correlate with the disposal locations and could be useful for validating some modeling assumptions. Detections are sporadic for Am-241, Cs-137, Cl-36, I-129, Np-237, plutonium, and Sr-90. Soil gas and atmospheric data collected near Soil Vault Rows 12 and 20 suggest that C-14 and H-3 are migrating from disposals of beryllium blocks and activated metal.

CONTENTS

ABSTRACT.....	iii
ACRONYMS.....	xvii
1. INTRODUCTION	1-1
1.1 Purpose and Scope.....	1-1
2. MONITORING AT THE RADIOACTIVE WASTE MANAGEMENT COMPLEX	2-1
2.1 Soil-Moisture Sampling.....	2-1
2.2 Soil-Gas Sampling.....	2-3
2.3 Aquifer Sampling	2-3
2.4 Monitoring of Organic Contaminants.....	2-9
3. RADIONUCLIDE CONTAMINANTS IN THE ENVIRONMENT	3-1
3.1 Americium-241	3-1
3.1.1 Waste Zone	3-1
3.1.2 Vadose Zone	3-1
3.1.3 Aquifer	3-4
3.1.4 Summary of Americium-241	3-6
3.2 Carbon-14.....	3-7
3.2.1 Waste Zone	3-7
3.2.2 Vadose Zone	3-10
3.2.3 Aquifer	3-14
3.2.4 Summary of Carbon-14	3-15
3.3 Chlorine-36.....	3-17
3.3.1 Waste Zone	3-17
3.3.2 Vadose Zone	3-17
3.3.3 Aquifer	3-20
3.3.4 Summary of Chlorine-36	3-21
3.4 Tritium.....	3-23
3.4.1 Waste Zone	3-23
3.4.2 Vadose Zone	3-25
3.4.3 Aquifer	3-32
3.4.4 Summary of Tritium	3-35

3.5	Iodine-129	3-37
3.5.1	Waste Zone	3-37
3.5.2	Vadose Zone	3-38
3.5.3	Aquifer.....	3-39
3.5.4	Summary of Iodine-129	3-39
3.6	Neptunium-237.....	3-43
3.6.1	Waste Zone	3-43
3.6.2	Vadose Zone	3-43
3.6.3	Aquifer.....	3-44
3.6.4	Summary of Neptunium-237	3-44
3.7	Plutonium	3-46
3.7.1	Waste Zone	3-46
3.7.2	Vadose Zone	3-46
3.7.3	Aquifer.....	3-52
3.7.4	Summary of Plutonium.....	3-55
3.8	Strontium-90.....	3-56
3.8.1	Waste Zone	3-56
3.8.2	Vadose Zone	3-56
3.8.3	Aquifer.....	3-57
3.8.4	Summary of Strontium-90	3-58
3.9	Technetium-99.....	3-60
3.9.1	Waste Zone	3-60
3.9.2	Vadose Zone	3-60
3.9.3	Aquifer.....	3-66
3.9.4	Summary of Technetium-99	3-66
3.10	Uranium.....	3-68
3.10.1	Waste Zone	3-69
3.10.2	Vadose Zone	3-69
3.10.3	Aquifer.....	3-77
3.10.4	Summary of Uranium	3-78
3.11	Other Radionuclide Contaminants.....	3-81
4.	ORGANIC CONTAMINANTS.....	4-1
4.1	Carbon Tetrachloride.....	4-1
4.1.1	Waste Zone	4-1
4.1.2	Vadose Zone	4-3
4.1.3	Aquifer.....	4-7
4.1.4	Summary of Carbon Tetrachloride	4-12

4.2	Tetrachloroethene	4-13
4.2.1	Waste Zone	4-13
4.2.2	Vadose Zone	4-14
4.2.3	Aquifer.....	4-14
4.2.4	Summary of Tetrachloroethene.....	4-15
4.3	Methylene Chloride	4-15
4.3.1	Waste Zone	4-15
4.3.2	Vadose Zone	4-15
4.3.3	Aquifer.....	4-16
4.3.4	Summary of Methylene Chloride	4-16
4.4	Other Organic Contaminants	4-17
4.4.1	Waste Zone	4-17
4.4.2	Vadose Zone	4-17
4.4.3	Aquifer.....	4-18
4.4.4	Summary.....	4-21
5.	INORGANIC CONTAMINANTS	5-1
5.1	Nitrates	5-1
5.1.1	Waste Zone	5-1
5.1.2	Vadose Zone	5-1
5.1.3	Aquifer.....	5-4
5.1.4	Summary of Nitrates	5-4
5.2	Other Inorganic Contaminants	5-5
5.2.1	Vadose Zone	5-6
5.2.2	Aquifer.....	5-7
5.2.3	Summary of Other Inorganic Contaminants	5-16
6.	SUMMARY	6-1
6.1	Summary in the Context of Low-Level Waste Disposal	6-1
6.1.1	Performance Assessment and Composite Analysis Source Monitoring Summary.....	6-1
6.1.2	Performance Assessment and Composite Analysis Vadose Zone Monitoring Summary.....	6-2
6.1.3	Performance Assessment and Composite Analysis Aquifer Monitoring Summary.....	6-3
6.2	Summary in the Context of the Comprehensive Environmental Response, Compensation, and Liability Act.....	6-3
7.	REFERENCES	7-1

FIGURES

1-1.	Map of the Idaho National Engineering and Environmental Laboratory showing the Radioactive Waste Management Complex and other major program sites.....	1-2
1-2.	Waste disposal locations at the Radioactive Waste Management Complex	1-4
2-1.	Location of focus areas at the Subsurface Disposal Area.....	2-4
2-2.	Locations of lysimeter monitoring wells in the 0- to 35-ft depth interval of the Subsurface Disposal Area	2-5
2-3.	Locations of lysimeter monitoring wells in the 35- to 140-ft depth interval of the Subsurface Disposal Area.....	2-6
2-4.	Locations of lysimeters and perched water monitoring wells in the >140-ft depth interval of the Subsurface Disposal Area	2-7
2-5.	Locations of aquifer-monitoring wells at the Radioactive Waste Management Complex	2-8
3-1.	Occurrences of americium-241 detections in the shallow lysimeters since Fiscal Year 1997	3-2
3-2.	Occurrences of americium-241 detections in intermediate-depth (35- to 140-ft) lysimeters since Fiscal Year 1997	3-3
3-3.	Occurrences of americium-241 detections in the deep-depth (>140 ft) lysimeters since Fiscal Year 1997	3-4
3-4.	Occurrences of americium-241 detections in aquifer samples around the Radioactive Waste Management Complex since Fiscal Year 1997	3-5
3-5.	Americium-241 disposal locations and vadose zone detection locations at the Subsurface Disposal Area	3-6
3-6.	Vapor probes, tensiometers, lysimeters, and soil-moisture probes installed in the waste zone near or in Soil Vault Rows 12 and 20	3-8
3-7.	Occurrences of carbon-14 detections in shallow lysimeters since Fiscal Year 1997	3-10
3-8.	Occurrences of carbon-14 detections in intermediate-depth (35 to 140 ft) lysimeters since Fiscal Year 1997	3-12
3-9.	Occurrences of carbon-14 detections in deep-depth (>140 ft) lysimeters since Fiscal Year 1997	3-13
3-10.	Occurrences of carbon-14 detections in the aquifer-monitoring wells since Fiscal Year 1997	3-14
3-11.	Carbon-14 disposal locations and vadose zone detection locations at the Subsurface Disposal Area	3-15

3-12. Occurrence of chlorine-36 detections in shallow lysimeters.....	3-18
3-13. Occurrences of chlorine-36 detections in intermediate-depth (35 to 140 ft) lysimeters.....	3-19
3-14. Occurrences of chlorine-36 detections in deep-depth (>140 ft) lysimeters.....	3-20
3-15. Occurrences of chlorine-36 detections in the aquifer-monitoring wells since Fiscal Year 1994.....	3-21
3-16. Airborne tritium concentration above the beryllium blocks at Subsurface Disposal Area Soil Vault Row 20	3-24
3-17. Tritium concentration in water vapor from the 8.9-ft-deep GSP-1 soil-gas sampling port.....	3-26
3-18. Tritium concentration in water vapor from the 15-ft-deep GSP-1 soil-gas sampling port.....	3-26
3-19. Tritium concentration in water vapor from the 20.3-ft-deep GSP-1 soil-gas sampling port.....	3-27
3-20. Occurrences of tritium detections in the shallow lysimeters since Fiscal Year 1997.....	3-28
3-21. Tritium concentration history for Lysimeter W06:L27 from April 1997 to June 2000	3-29
3-22. Occurrences of tritium detections in intermediate-depth (35- to 140-ft) lysimeters since Fiscal Year 1997.....	3-30
3-23. Tritium concentration history for Lysimeter TW1:DL04.....	3-31
3-24. Occurrences of tritium detections in the deep-depth (>140 ft) lysimeters since Fiscal Year 1997.....	3-32
3-25. Occurrences of tritium detections in the aquifer since Fiscal Year 1997	3-34
3-26. Comparison of tritium concentration time histories showing the observed effects of radioactive decay (•) and dilution and dispersion (Test Reactor Area well); and the observed effects of radioactive decay (•) with no apparent dilution and dispersion (Radioactive Waste Management Complex well)	3-35
3-27. Occurrences of iodine-129 detections in shallow lysimeter wells.....	3-38
3-28. Occurrences of iodine-129 detections in Radioactive Waste Management Complex aquifer wells	3-40
3-29. Iodine-129 disposal locations and vadose zone detection locations at the Subsurface Disposal Area	3-41
3-30. Occurrences of plutonium-238 in shallow lysimeter samples	3-47
3-31. Occurrences of plutonium-239/240 detections in shallow lysimeters since Fiscal Year 1997.....	3-48
3-32. Occurrences of plutonium-238 detections in intermediate-depth lysimeters since Fiscal Year 1997	3-49

3-33. Occurrences of plutonium-239/240 detections in intermediate-depth lysimeters since Fiscal Year 1997	3-50
3-34. Occurrences of plutonium-238 detections in deep lysimeters since Fiscal Year 1997	3-51
3-35. Occurrences of plutonium-239/240 detections in deep lysimeters since Fiscal Year 1997	3-52
3-36. Occurrences of plutonium-238 detections in aquifer samples collected around the Radioactive Waste Management Complex since Fiscal Year 1997	3-53
3-37. Occurrences of plutonium-239/240 detections in aquifer samples collected around the Radioactive Waste Management Complex since Fiscal Year 1997	3-54
3-38. Plutonium disposal locations and vadose zone detection locations at the Subsurface Disposal Area	3-55
3-39. Plutonium concentration time history associated with Subsurface Disposal Area vadose zone and Radioactive Waste Management Complex aquifer monitoring for Fiscal Year 2003.....	3-56
3-40. Occurrences of strontium-90 in shallow lysimeter samples since Fiscal Year 1997.....	3-57
3-41. Strontium-90 disposal locations and vadose zone detection locations at the Subsurface Disposal Area	3-59
3-42. Occurrences of technetium-99 detections in shallow lysimeters since Fiscal Year 1997	3-61
3-43. Occurrences of technetium-99 detections in intermediate-depth lysimeters since Fiscal Year 1997.....	3-63
3-44. Lysimeter D06-DL01 Tc-99 concentration history since monitoring began in 1998.....	3-64
3-45. Occurrences of technetium detections in lysimeters at depths >140 ft since Fiscal Year 1997.....	3-65
3-46. Occurrences of technetium-99 in aquifer samples collected in the vicinity of the Radioactive Waste Management Complex since Fiscal Year 1997	3-67
3-47. Disposals and vadose zone detections of technetium-99.....	3-68
3-48a. Uranium-233/234 in select lysimeters from the shallow vadose zone, April 1998 through July 2003	3-71
3-48b.Uranium-235/236 in select lysimeters from the shallow vadose zone, April 1998 through July 2003	3-71
3-48c. Uranium-238 in select lysimeters from the shallow vadose zone, April 1998 through July 2003	3-72
3-49a. Uranium-238/235 activity ratios for the PA01-L15 shallow lysimeter from April 1998 through July 2003	3-72

3-49b. Uranium-238/235 activity ratios for the PA02-L16 shallow lysimeter from April 1998 through July 2003	3-72
3-49c. Uranium-238/235 activity ratios for the W23-L07 and W23-L09 shallow lysimeters from August 1998 through July 2003.....	3-72
3-50a. Uranium-233/234 in mid-depth lysimeters, March 1997 through July 2003	3-75
3-50b. Uranium-235/236 in mid-depth lysimeters, March 1997 through July 2003	3-75
3-50c. Uranium-238 in mid-depth lysimeters, March 1997 through July 2003	3-75
3-51a. Uranium-238:235 activity ratio in D06-DL01 and D06-DL02 over time	3-75
3-51b. Uranium-238:235 activity ratio in TW1-DL04 over time	3-75
3-52a. Uranium-233/234 data from Well USGS-92, April 1998 through July 2003	3-77
3-52b. Uranium-238 data from Well USGS-92, April 1998 through July 2003.....	3-77
3-53. Uranium disposal locations and vadose zone detection locations at the Subsurface Disposal Area	3-81
4-1. History of carbon tetrachloride concentration in Well USGS-92.....	4-4
4-2a. Location of soil-gas sampling wells in the vicinity of the Radioactive Waste Management Complex.....	4-5
4-2b. Depth of the sampling ports in wells in the vicinity of the Radioactive Waste Management Complex	4-6
4-3. Carbon tetrachloride soil-gas concentration time history for selected ports in Well 8801.....	4-8
4-4. Carbon tetrachloride soil-gas concentration time history for selected ports in Well 9301.....	4-9
4-5. Carbon tetrachloride soil-gas concentration time history for selected ports in Well 9V.....	4-10
4-6. Carbon tetrachloride aquifer concentrations in monitoring wells in the vicinity of the Radioactive Waste Management Complex.....	4-13
5-1. Lysimeters in the Subsurface Disposal Area vadose zone exhibiting concentration trends.....	5-3
5-2. Concentration of nitrates (as nitrogen) in Radioactive Waste Management Complex Aquifer Monitoring Well M6S from 1992 to August 2003.....	5-5
5-3. Radioactive Waste Management Complex aquifer-monitoring wells exhibiting increasing concentrations of chromium	5-13
5-4. Total chromium concentrations in aquifer wells near the Radioactive Waste Management Complex.....	5-14

TABLES

1-1.	Contaminants of interest to the Performance Assessment and Composite Analysis Monitoring Program and Operable Unit 7-13/14	1-3
2-1.	Analytical priorities for Fiscal Year 2003	2-2
3-1.	Specific activity of carbon-14 (pCi [C-14]/g [C]) from vapor probes at Soil Vault Row 12	3-8
3-2.	Summary of carbon-14-specific activity (pCi [C-14]/g [C]) in CO ₂ from soil-gas samples collected at Soil Vault Row 20	3-9
3-3.	Carbon-14 detection in Fiscal Year 2003 Subsurface Disposal Area vadose zone soil-moisture samples from the 35- to 140-ft depth interval	3-11
3-4.	Summary of maximum concentrations of carbon-14 in vadose zone soil-moisture and perched water samples at the Radioactive Waste Management Complex from Fiscal Year 1997 through 2003	3-16
3-5.	Summary of maximum concentrations of carbon-14 in aquifer wells at the Radioactive Waste Management Complex from Fiscal Year 1997 through 2003	3-17
3-6.	Chlorine-36 detections in Fiscal Year 2003 Subsurface Disposal Area vadose zone soil-moisture samples from the 0- to 35-ft depth interval	3-18
3-7.	Chlorine-36 detections in Fiscal Year 2003 Subsurface Disposal Area vadose zone soil-moisture samples from the 35- to 140-ft depth interval	3-19
3-8.	Chlorine-36 detection in Fiscal Year 2003 Subsurface Disposal Area vadose zone s oil-moisture and perched water samples from depths greater than 140 ft	3-20
3-9.	Summary of maximum concentrations of chlorine-36 in vadose zone soil-moisture and perched water samples at the Radioactive Waste Management Complex from Fiscal Years 1997 through 2003	3-22
3-10.	Summary of maximum concentrations of chlorine-36 in aquifer wells at the Radioactive Waste Management Complex from Fiscal Years 1997 through 2003	3-23
3-11.	Estimated annual emission of tritium to air from buried activated beryllium at Soil Vault Row 20.....	3-25
3-12.	Tritium detections in Fiscal Year 2003 Subsurface Disposal Area vadose zone soil-moisture samples from the 0- to 35-ft depth interval	3-27
3-13.	Tritium detections in Fiscal Year 2003 Subsurface Disposal Area vadose zone soil-moisture samples from the 35- to 140-ft depth interval	3-29
3-14.	Tritium detected above aquifer background concentrations.....	3-33

3-15. Summary of maximum concentrations of tritium in vadose zone soil-moisture and perched water samples at the Radioactive Waste Management Complex from Fiscal Year 1997 through 2003	3-36
3-16. Summary of maximum concentrations of tritium in aquifer wells at the Radioactive Waste Management Complex from Fiscal Year 1997 through 2003	3-37
3-17. Summary of maximum concentrations of iodine-129 in vadose zone soil-moisture and perched water samples at the Radioactive Waste Management Complex from Fiscal Year 1997 through 2003	3-42
3-18. Summary of maximum concentrations of iodine-129 in aquifer wells at the Radioactive Waste Management Complex from Fiscal Year 1997 through 2003	3-43
3-19. Summary of maximum concentrations of neptunium-237 in soil-moisture and perched water samples at the Radioactive Waste Management Complex from Fiscal Year 1997 through 2003.....	3-44
3-20. Summary of maximum concentrations of neptunium-237 in aquifer wells at the Radioactive Waste Management Complex from Fiscal Year 1997 through 2003	3-45
3-21. Technetium-99 detections in Fiscal Year 2003 Subsurface Disposal Area vadose zone soil-moisture samples from the 0- to 35-ft depth interval	3-60
3-22. Technetium-99 detections in Fiscal Year 2003 Subsurface Disposal Area vadose zone soil-moisture samples from the 35- to 140-ft depth interval	3-62
3-23. Technetium-99 detections in Fiscal Year 2003 Subsurface Disposal Area vadose zone soil-moisture samples from the 140- to 250-ft depth interval	3-64
3-24. Isotopic uranium results above local soil-moisture background in the 0- to 35-ft depth interval.....	3-69
3-25. Isotopic uranium results above local soil-moisture background in the 35- to 140-ft depth interval.....	3-73
3-26. Isotopic uranium results above local soil-moisture background in the 140- to 250-ft depth interval.....	3-76
3-27. Isotopic uranium results above aquifer background levels.....	3-77
3-28. Summary of maximum detected concentrations of uranium-233/234 from aquifer wells in the vicinity of the Radioactive Waste Management Complex since Fiscal Year 1997	3-78
3-29. Summary of maximum detected concentrations of uranium-238 from aquifer wells in the vicinity of the Radioactive Waste Management Complex since Fiscal Year 1997	3-78
3-30. Summary of maximum detections of uranium-238 in vadose zone soil-moisture and perched water samples at the Radioactive Waste Management Complex from Fiscal Year 1997 through 2003.....	3-79

3-31. Summary of maximum detections of uranium-233/234 in vadose zone soil-moisture and perched water samples at the Radioactive Waste Management Complex from Fiscal Year 1997 through 2003	3-80
4-1. Volatile organic compound vapor concentration results from Subsurface Disposal Area vapor probes in Fiscal Year 2003. All analyses were performed with the INNOVA gas analyzer except where noted. The Southwest Laboratory of Oklahoma and the Idaho National Engineering and Environmental Laboratory Environmental Chemistry Laboratory analyses were performed with gas chromatography/mass spectrometry	4-2
4-2. Carbon tetrachloride results above quantitation limit (Waste Area Group 7) or minimum reporting level in the aquifer in the vicinity of the Radioactive Waste Management Complex	4-10
4-3. Fiscal Year 2003 methylene chloride vapor concentration results from Subsurface Disposal Area soil vapor probes.....	4-16
4-4. Maximum concentrations of trichloroethene, 1,1,1-trichloroethane, chloroform, and Freon-113 detected in soil gas from waste zone vapor probes.....	4-17
4-5. Concentrations of other organic compounds detected in a perched water sample from Well USGS-92 in Fiscal Year 2003	4-18
4-6. Maximum concentrations of trichloroethene, 1,1,1-trichloroethane, and chloroform detected in vadose zone soil gas inside and outside the Subsurface Disposal Area in Fiscal Year 2003.....	4-18
4-7. Historic maximum concentrations of trichloroethene, 1,1,1-trichloroethane, and chloroform detected in vadose zone soil gas inside and outside the Subsurface Disposal Area.....	4-18
4-8. Concentration of volatile organic compounds detected in the aquifer in the vicinity of the Radioactive Waste Management Complex in Fiscal Year 2003	4-19
5-1. Positive detections of nitrate concentrations above local soil-moisture background in the 0- to 35-ft depth interval of the Subsurface Disposal Area vadose zone soil moisture (lysimeter).....	5-2
5-2. Positive detections of nitrate concentrations above local soil-moisture background in the 35-to 140-ft depth interval of the Subsurface Disposal Area vadose zone soil moisture (lysimeter).....	5-3
5-3. Positive detections of nitrate concentrations above local soil-moisture background in the 140- to 250-ft depth interval of the Subsurface Disposal Area vadose zone soil moisture (lysimeter).....	5-4
5-4. Nitrate (as nitrogen) aquifer concentrations detected above background at the Radioactive Waste Management Complex in Fiscal Year 2003	5-5
5-5. Positive detections of anions and metals above local soil-moisture background in Subsurface Disposal Area vadose zone soil-moisture (lysimeter) samples, excluding brine contaminants	5-7

5-6. Anions and metals concentrations in excess of aquifer background levels or maximum contaminant levels	5-8
6-1. Summary of radionuclide detections in vadose zone soil-moisture and perched water samples from the Radioactive Waste Management Complex from Fiscal Year 1997 through 2003.....	6-2
6-2. Summary of aquifer sampling results for radionuclides at the Radioactive Waste Management Complex from Fiscal Year 1997 through 2003	6-4

ACRONYMS

bls	below land surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	contaminant of concern
CPP	Chemical Processing Plant
CY	calendar year
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FY	fiscal year
GC/MS	gas chromatography/mass spectrometry
GSP	gas sampling port
HDPE	high-density polyethylene
INEEL	Idaho National Engineering and Environmental Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
MCL	maximum contaminant level
MDA	minimum detectable activity
OCVZ	organic contamination in the vadose zone
OU	operable unit
PA/CA	performance assessment and composite analysis
PCE	tetrachloroethene
RBC	risk-based concentration
RFP	Rocky Flats Plant
RWMC	Radioactive Waste Management Complex
SDA	Subsurface Disposal Area
SRPA	Snake River Plain Aquifer

SVR	soil vault row
TCA	trichloroethane
TCE	trichloroethene
TRA	Test Reactor Area
TRU	transuranic
USC	United States Code
USGS	United States Geological Survey
VOC	volatile organic compound
VVET	vapor vacuum extraction with treatment
WAG	waste area group

Fiscal Year 2003 Environmental Monitoring Report for the Radioactive Waste Management Complex

1. INTRODUCTION

The Radioactive Waste Management Complex (RWMC) at the Idaho National Engineering and Environmental Laboratory (INEEL) has been used for waste disposal operations since the 1950s. The RWMC occupies about 177 acres (71.6 ha) in the southwestern quadrant of the INEEL (see Figure 1-1), and it is divided into three areas: (1) the Subsurface Disposal Area (SDA), where radioactive and hazardous waste has been disposed of; (2) the Transuranic Storage Area; and (3) the administration and operations area. Contaminant concentrations are monitored routinely within and around the RWMC in soil gas, soil moisture, and the Snake River Plain Aquifer (SRPA) to determine whether waste buried in the SDA is impacting the environment. In addition, special studies are conducted to determine whether contaminants can be detected in the atmosphere and other media. Results from these hydrological monitoring activities are used to support the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 USC § 9601 et seq.) risk assessment in the Clean/Close RWMC Project and the Performance Assessment and Composite Analysis (PA/CA) Monitoring Program in the Landfills and Waste Disposal Project.

This report is a joint effort of the Clean/Close RWMC Project and the Landfills and Waste Disposal Project to compile environmental monitoring results for the RWMC from Fiscal Year (FY) 1997 through FY 2003, with emphasis on recent results. Data prior to FY 2003 are presented to evaluate the presence or absence of contaminant trends.

1.1 Purpose and Scope

Monitoring results summarized in this report are used to satisfy several requirements and needs. The Landfills and Waste Disposal Project uses the results to comply with requirements of U.S. Department of Energy (DOE) Order 435.1, "Radioactive Waste Management," Chapter IV, and the associated implementation manual and guidance, which require monitoring of low-level radioactive waste disposal facilities. In particular, the following requirements of DOE Order 435.1 must be addressed:

- Site-specific PA/CA will be used to determine the media, locations, radionuclides, and other substances to be monitored.
- The environmental monitoring program will be designed to include measuring and evaluating releases and migration of radionuclides.
- The environmental monitoring program will be capable of detecting changing trends in performance to allow application of necessary corrective action before exceeding the performance assessment objectives. The performance objectives (i.e., action levels) for FY 2002 are discussed and compared with monitoring results in the PA/CA annual review (Parsons, McCarthy, and Seitz 2003).

The Clean/Close RWMC Program uses the monitoring results to support activities associated with the ongoing CERCLA risk assessment for Waste Area Group (WAG) 7, which comprises the RWMC. Operable Unit (OU) 7-13/14 is the designation for the comprehensive operable unit for WAG 7 recognized under the *Federal Facility Agreement and Consent Order for the Idaho National Engineering Laboratory* (DOE-ID 1991) and CERCLA (42 USC § 9601 et seq.).

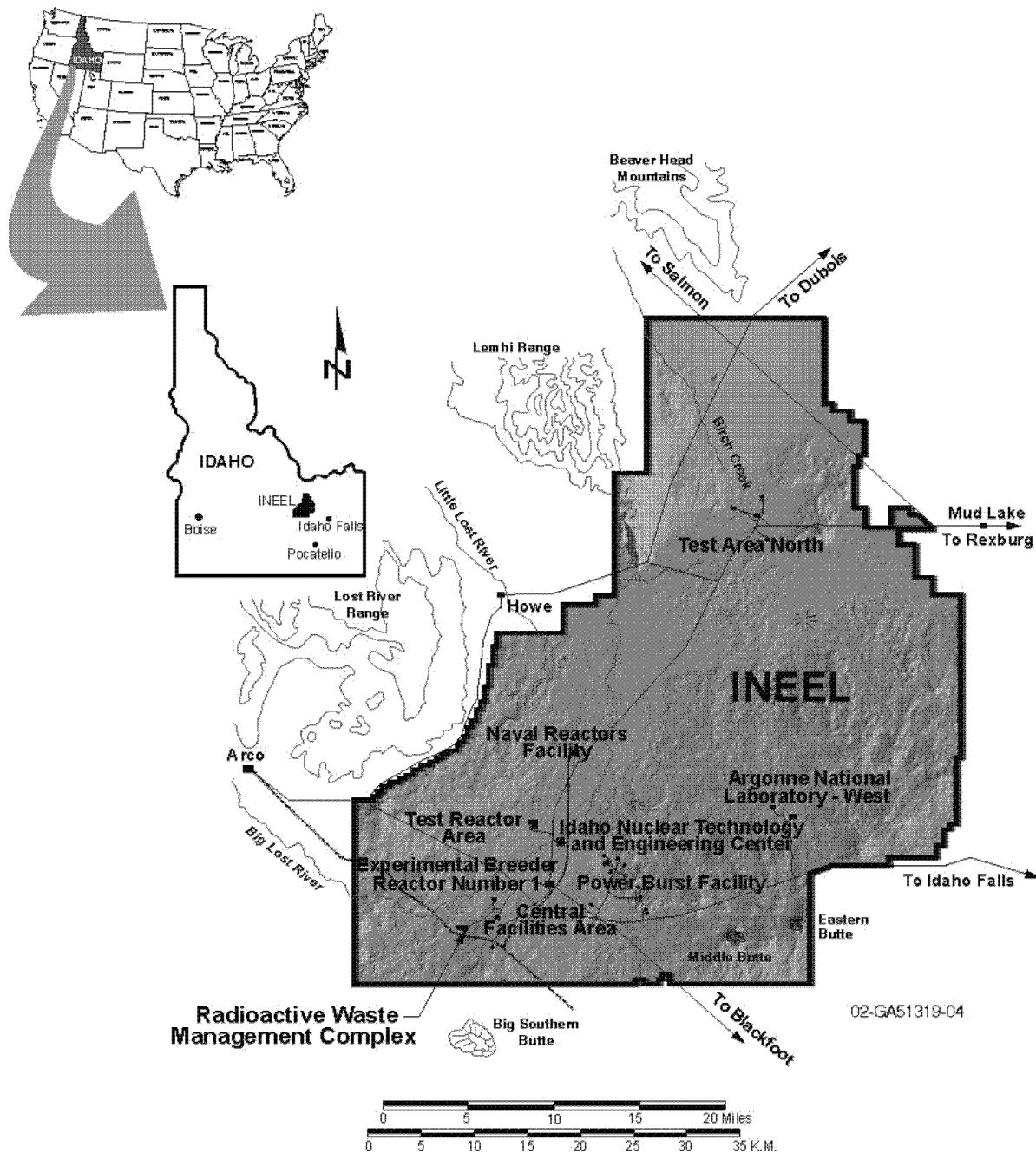


Figure 1-1. Map of the Idaho National Engineering and Environmental Laboratory showing the Radioactive Waste Management Complex and other major program sites.

Environmental monitoring data are used to support the following OU 7-13/14 objectives:

- Assess whether contaminants are being released from the waste zone
- Provide baseline data to choose monitoring locations to support the upcoming, comprehensive record of decision for OU 7-13/14
- Provide modelers with candidate calibration targets
- Verify conservatism in risk assessment modeling.

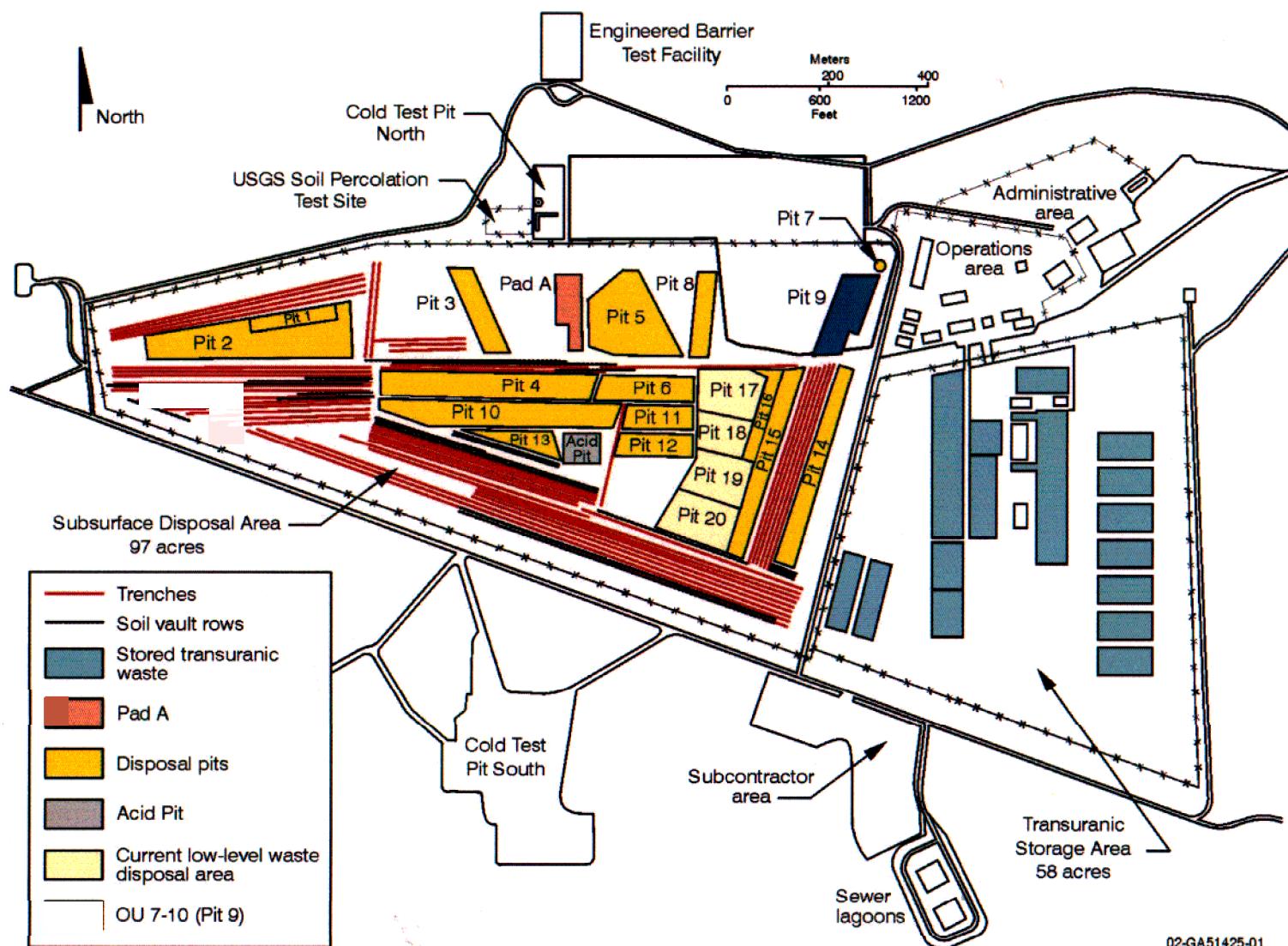
Monitoring priorities are established by collaboration between the Clean/Close RWMC Project and Landfills and Waste Disposal Project and other data users. The required data for the RWMC PA/CA Monitoring Program are identified in the *Performance Assessment and Composite Analysis Monitoring Program* description (McCarthy, Seitz, and Ritter 2001). Contaminants of concern (COCs) for the CERCLA risk assessment are identified in *Ancillary Basis for Risk Analysis of the Subsurface Disposal Area* (Holdren et al. 2002) and include radionuclides plus some organics and nitrates. Table 1-1 summarizes contaminants of interest for the two programs.

Figure 1-2 shows the layout of disposal units at the SDA. More detailed maps of the SDA, additional information on the environmental setting and history of disposal operations at the SDA, and the disposal inventory are presented in the *Ancillary Basis for Risk Analysis of the Subsurface Disposal Area* (Holdren et al. 2002).

Table 1-1. Contaminants of interest to the Performance Assessment and Composite Analysis Monitoring Program and Operable Unit 7-13/14.

Contaminants of Interest to the Performance Assessment and Composite Analysis Monitoring Program	Contaminants of Interest to Operable Unit 7-13/14
C-14	Am-241
Cl-36	C-14
I-129	H-3 (potential calibration target)
Np-237	I-129
U-234	Nb-94
U-238	Np-237
	Plutonium (special-case contaminant)
	Sr-90
	Tc-99
	U-233
	U-234
	U-235
	U-236
	U-238
	Carbon tetrachloride
	Methylene chloride
	Nitrates
	Tetrachloroethylene

1-4



02-GA51425-01

Figure 1-2. Waste disposal locations at the Radioactive Waste Management Complex.

2. MONITORING AT THE RADIOACTIVE WASTE MANAGEMENT COMPLEX

Environmental samples are collected routinely within and around the RWMC area and analyzed for a variety of radionuclide, nonradionuclide, and organic contaminants that are potential risk drivers. The routine monitoring program supporting Clean/Close RWMC Project and Landfills and Waste Disposal Project objectives focuses on sampling the waste zone, the vadose zone, and the aquifer, including soil moisture, soil vapor and gas, perched water, and aquifer sampling. The soil moisture, soil gas and vapor, and aquifer-monitoring networks are described in the following subsections. Following Section 2, analytical results are presented by discipline with Section 3 containing results from radionuclide analyses, Section 4 containing results from organic analyses, and Section 5 containing results from inorganic analyses. Results for each contaminant are presented by monitoring zone: waste zone, vadose zone, and aquifer. In contrast to vadose zone samples in the 0–35-ft depth interval, waste zone samples were collected near waste with the intention of characterizing the waste zone. Vadose zone depth intervals are detailed below:

- 0–35 ft, not including samples collected from the waste zone. Vadose zone samples from this depth interval were located some distance away from waste disposals, either between, beside, or away from pits or trenches in the SDA.
- 35–140 ft, which includes the A-B and B-C interbeds.
- Greater than 140 ft deep.

Summary tables and maps are presented for each contaminant, as appropriate. Time histories of monitoring results also are presented graphically to aid in understanding the evaluation discussions.

2.1 Soil-Moisture Sampling

Soil-moisture samples are collected quarterly with suction lysimeters throughout the waste and vadose zones of the SDA. Installation of lysimeters in the SDA began in 1985 with the Subsurface Investigation Program and continues today based on emerging interests and needs. A description of how the lysimeters are installed is provided in Section 2 of the *Ancillary Basis for Risk Analysis of the Subsurface Disposal Area* (Holdren et al. 2002).

Lysimeter samples are limited in volume. Some lysimeters yield only a few milliliters per sampling event, while others occasionally yield up to approximately 900 mL. Of note for vadose zone monitoring in FY 2003, soil-moisture sample volumes have increased despite relatively dry weather. Increased volumes are attributable to improvements in sampling techniques. Several measures have been applied successfully, including upgrading surface hardware to minimize vacuum leaks, collecting samples at optimal sampling intervals, and applying continuous vacuum for a longer period. Lysimeter sample volumes have been sufficient to complete most analyses identified on the vadose zone analytical priority list for OU 7-13/14. Because not all analyses of interest can be performed with the limited sample volume, analytical priorities have been established for the lysimeter samples. The priorities were revised based on collaboration between the Clean/Close RWMC Project and the Landfills and Waste Disposal Project and are provided in Table 2-1.

Table 2-1. Analytical priorities for Fiscal Year 2003.

Priority	Preservative	Titrate (mL)	Container			
			250-mL HDPE (mL)	500-mL HDPE (mL)	100-mL HDPE (mL)	100-mL HDPE (mL)
January–March						
C-14	None	—	50	—	—	—
Tc-99/gamma	Acid	—	—	50	—	—
U/Pu/Am	Acid	—	—	50	—	—
H-3	None	—	50	—	—	—
Cl-36	Acid	—	—	50	—	—
I-129	None	—	50	—	—	—
Np-237	Acid	—	—	50	—	—
Anions	Chill, 24 hr	—	—	—	25	—
Metals	Acid	—	—	—	—	25
April–June						
Anions	Chill, 24 hr	—	—	—	25	—
pH/Alkalinity	Field titrate	25	—	—	—	—
Metals	Acid	—	—	—	—	25
Cl-36	Acid	—	—	50	—	—
Tc-99	None	—	50	—	—	—
U/Pu/Am	Acid	—	—	50	—	—
C-14	None	—	50	—	—	—
July–September						
C-14	None	—	50	—	—	—
Gamma/Tc-99	Acid	—	—	50	—	—
U/Pu/Am	Acid	—	—	50	—	—
H-3	None	—	50	—	—	—
Cl-36	Acid	—	—	50	—	—
I-129	None	—	50	—	—	—
Np-237	Acid	—	—	50	—	—
Anions	Chill, 24 hr	—	—	—	25	—
Metals	Acid	—	—	—	—	25
October–December						
C-14	None	—	50	—	—	—
Gamma/Tc-99	Acid	—	—	50	—	—
U/Pu/Am	Acid	—	—	50	—	—
Anions	Chill, 24 hr	—	—	—	25	—
Metals	Acid	—	—	—	—	25
H-3	None	—	50	—	—	—
Cl-36	Acid	—	—	50	—	—
I-129	None	—	50	—	—	—
Np-237	Acid	—	—	50	—	—

HDPE = high-density polyethylene

Locations for the 18 waste-zone lysimeters were chosen based on a need to investigate specific focus areas. The waste-zone lysimeters were placed from 1.5 to about 9 m (5 to about 30 ft) deep and are in or just below the target waste, at the point of waste and underburden contact, or at the point of contact with the underlying basalt. Locations of the focus areas are shown in Figure 2-1. The number of lysimeters per focus area is as follows:

- Two in the Uranium/Enriched Uranium Focus Area
- Two in the Americium/Neptunium Focus Area
- Six in the Organic Sludge Focus Area
- Six in the Depleted Uranium Focus Area
- Two in the Activated Metal Focus Area near Soil Vault Row (SVR) 12.

Only one waste-zone lysimeter yielded a soil-moisture sample during FY 2003. Approximately 10 mL of sample was extracted from Lysimeter 741-08-L1 in September 2003.

Twenty-nine sampled lysimeters are in the shallow vadose zone (0 to 11 m [0 to 35 ft] deep) (see Figure 2-2), and 15 lysimeters are in the intermediate vadose zone (11 to 43 m [35 to 140 ft] deep) (see Figure 2-3). Unlike the waste-zone lysimeters, the shallow vadose-zone lysimeters are located adjacent to the waste in undisturbed sediments, not within disposal units or next to waste. The intermediate vadose-zone lysimeters are located beneath the depth of the waste zone, generally in basalt or interbed sediments.

At a depth greater than 43 m (140 ft), both lysimeters and perched water wells provide samples (see Figure 2-4). Samples from Wells U.S. Geological Survey (USGS) -092 and -8802D are used to collect perched water from above the 67-m (220-ft) interbed.

2.2 Soil-Gas Sampling

Soil-gas samples are collected routinely from the SDA subsurface for analysis of volatile organic compounds (VOCs). Sample locations for VOCs and additional details are provided in the discussion of organic contaminant monitoring (see Section 4). Other soil-gas samples are collected from near buried beryllium reflector blocks to determine the extent of C-14 and H-3 releases. These sample locations and additional details are provided in the discussion of C-14 (Section 3.2) and H-3 (Section 3.4).

2.3 Aquifer Sampling

The INEEL collects aquifer samples on a quarterly basis. The USGS also collects data, but the data are not immediately available for use; therefore, the USGS data are not included here (except for organic contaminants). Aquifer well locations are shown in Figure 2-5. Well M10S has been out of commission since the end of 2000. A replacement well (S1835) was drilled in 2003, but the well has a very low yield, and drilling muds used in its construction remain in the hole. Because of the high turbidity, elevated total organic carbon and low yield, it was decided that samples would not be collected from this well for routine monitoring.

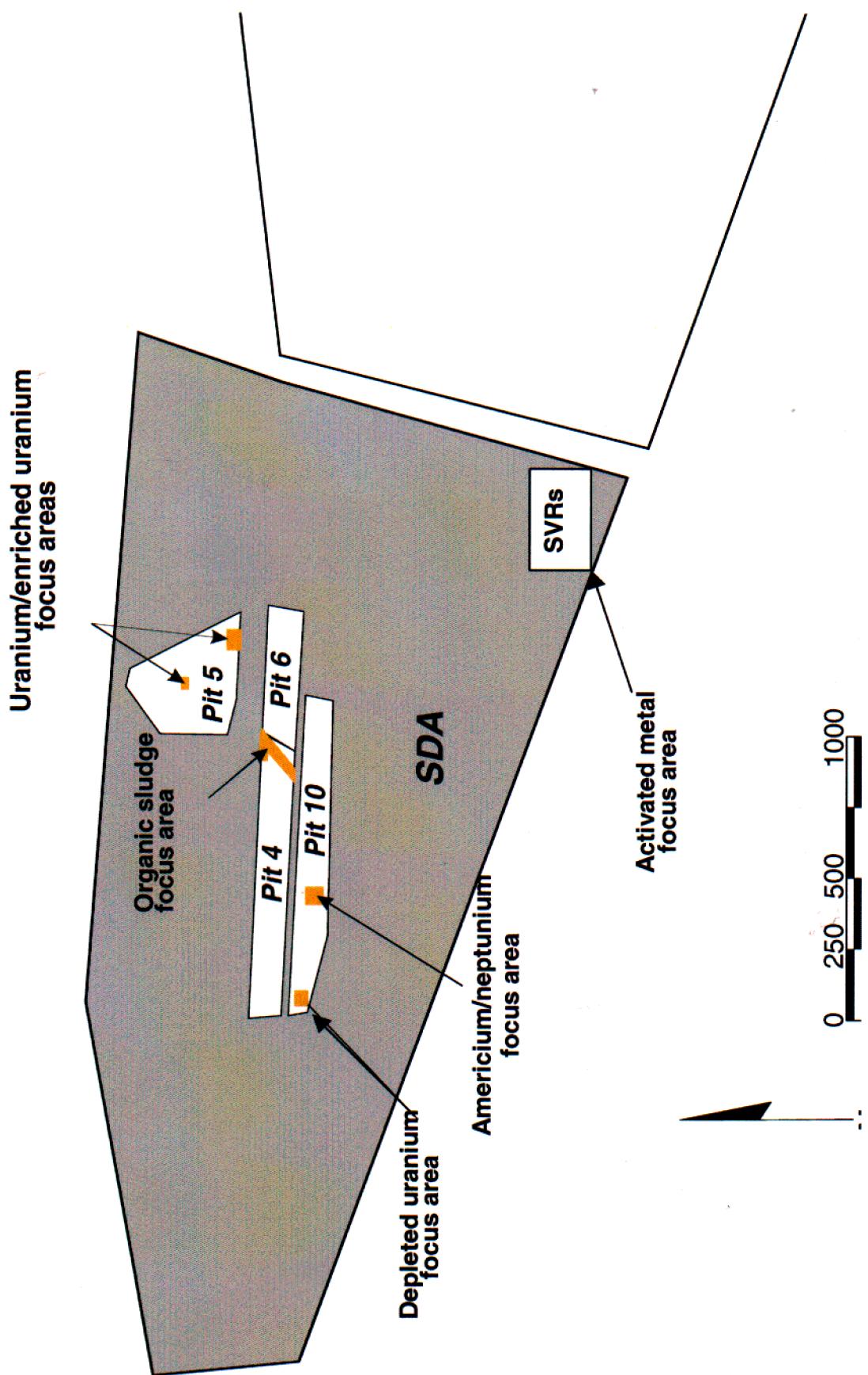


Figure 2-1. Location of focus areas at the Subsurface Disposal Area.

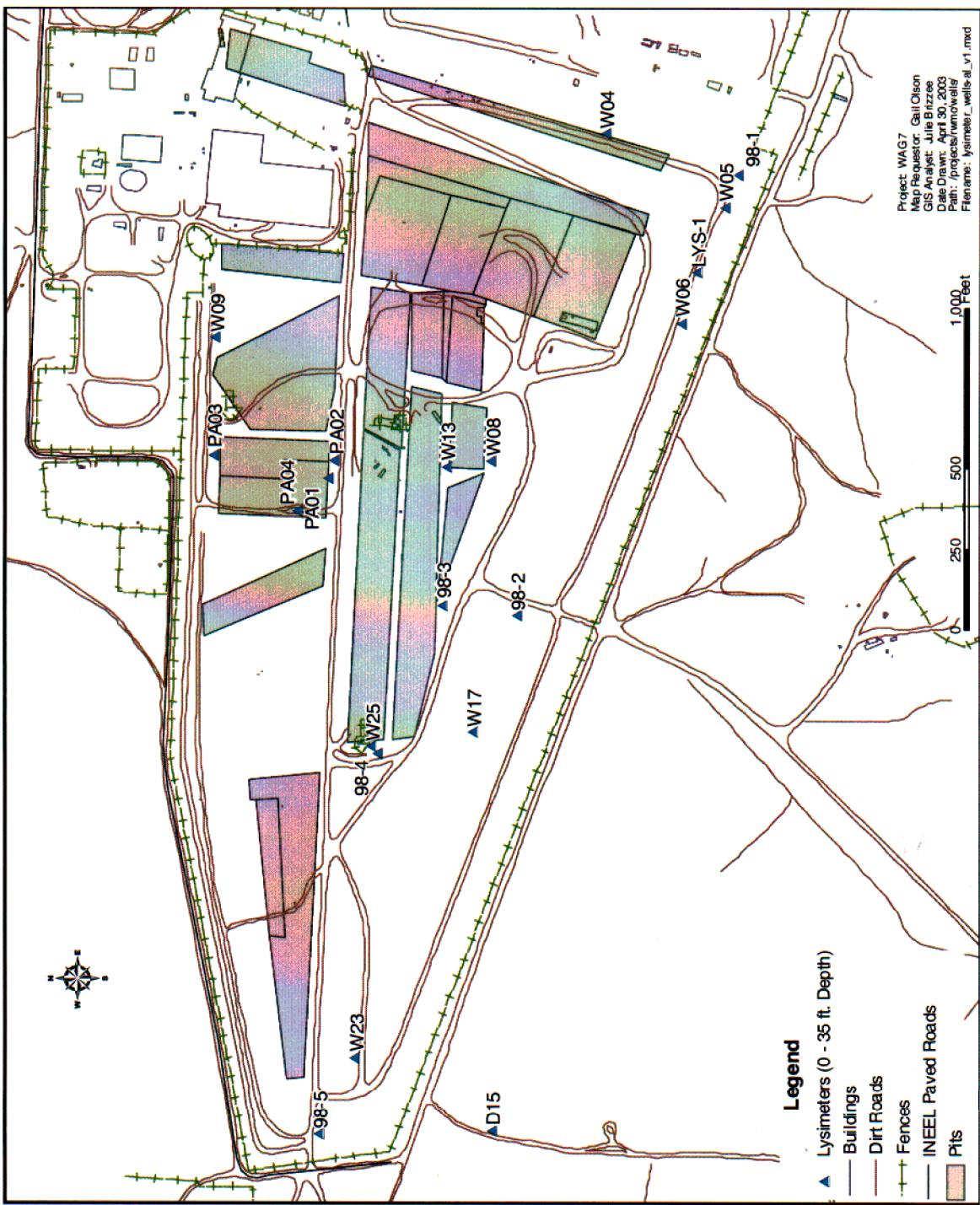


Figure 2-2. Locations of lysimeter monitoring wells in the 0- to 35-ft depth interval of the Subsurface Disposal Area.

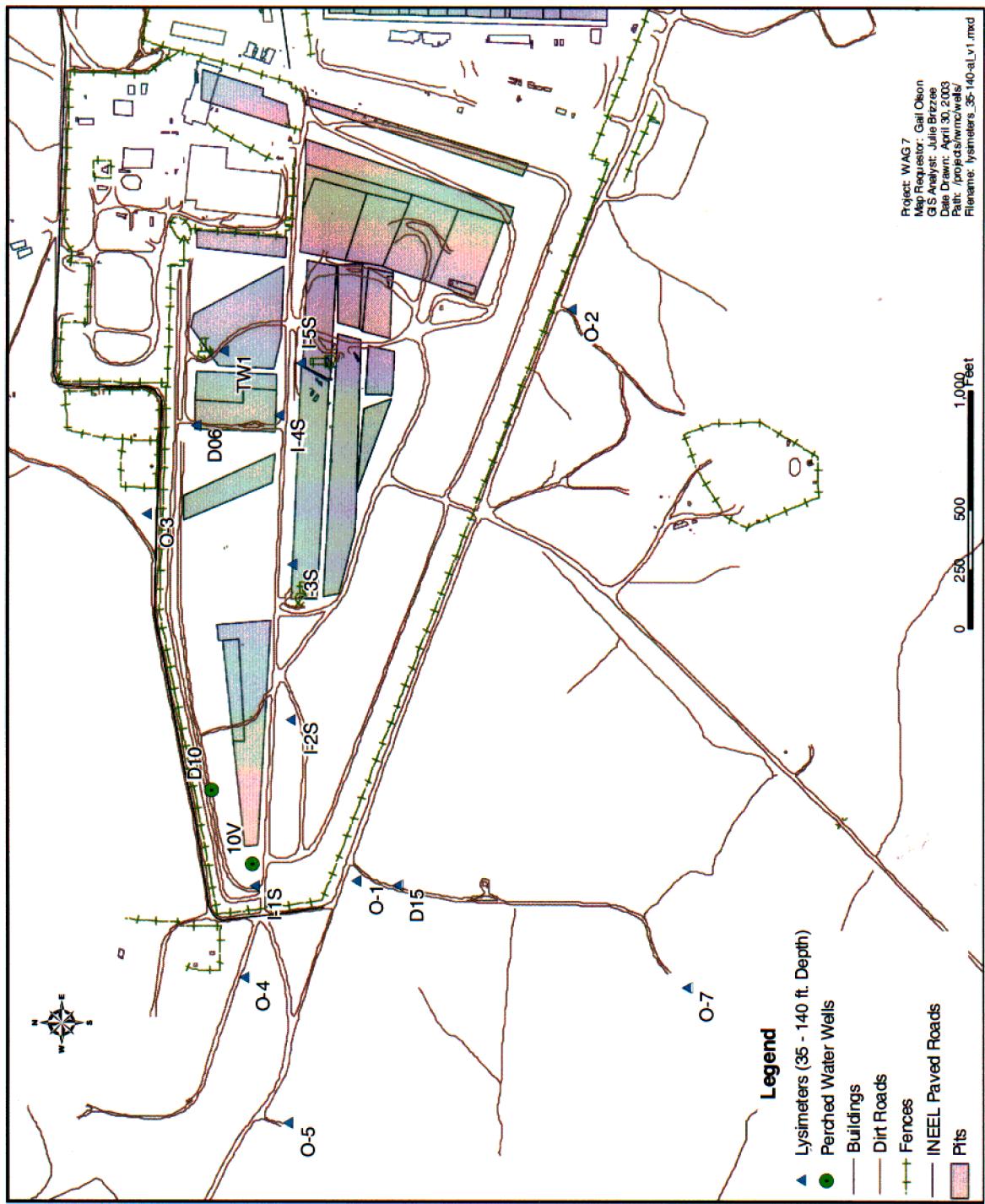


Figure 2-3. Locations of lysimeter monitoring wells in the 35- to 140-ft depth interval of the Subsurface Disposal Area.

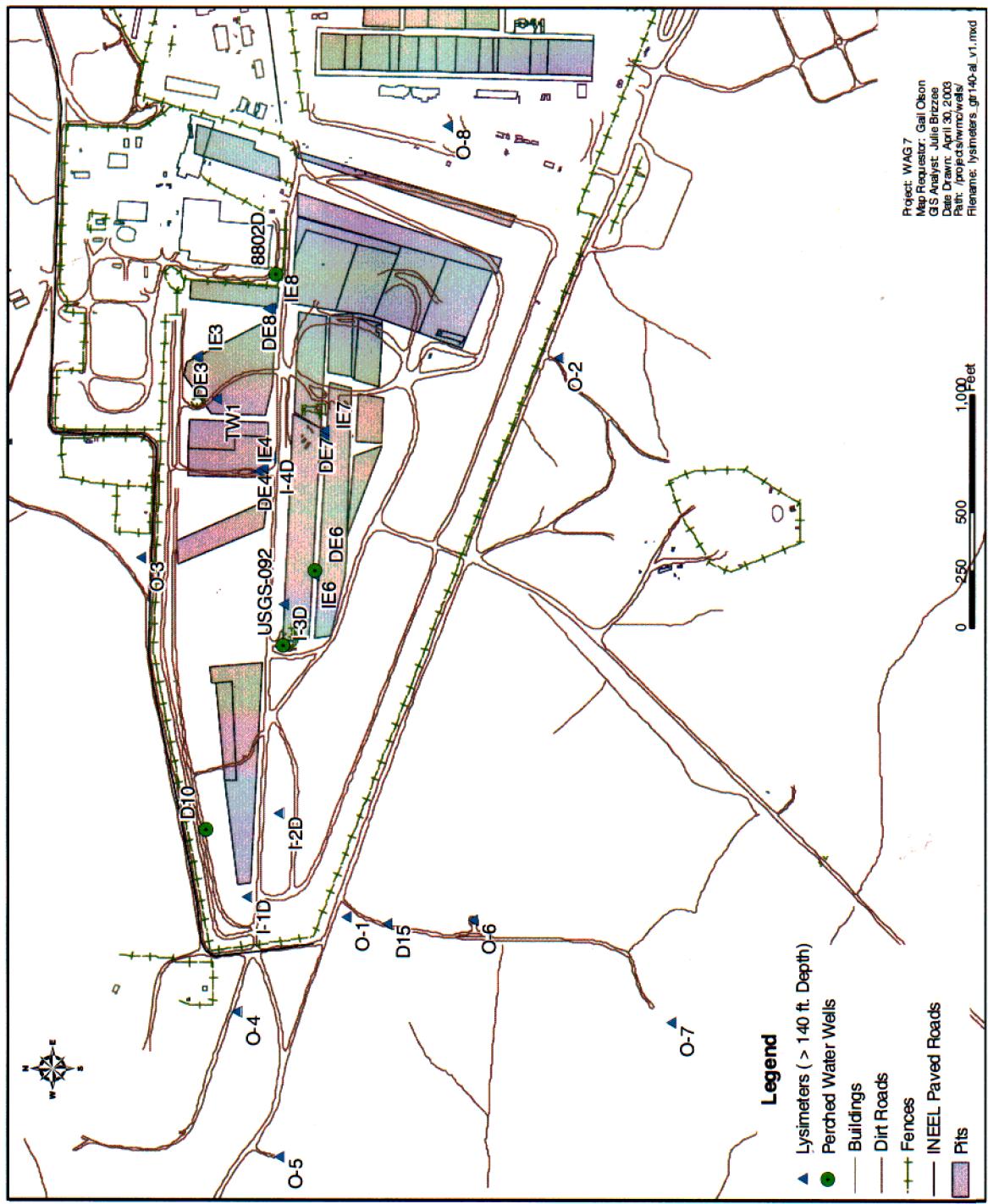


Figure 2-4. Locations of lysimeters and perched water monitoring wells in the >140-ft depth interval of the Subsurface Disposal Area.

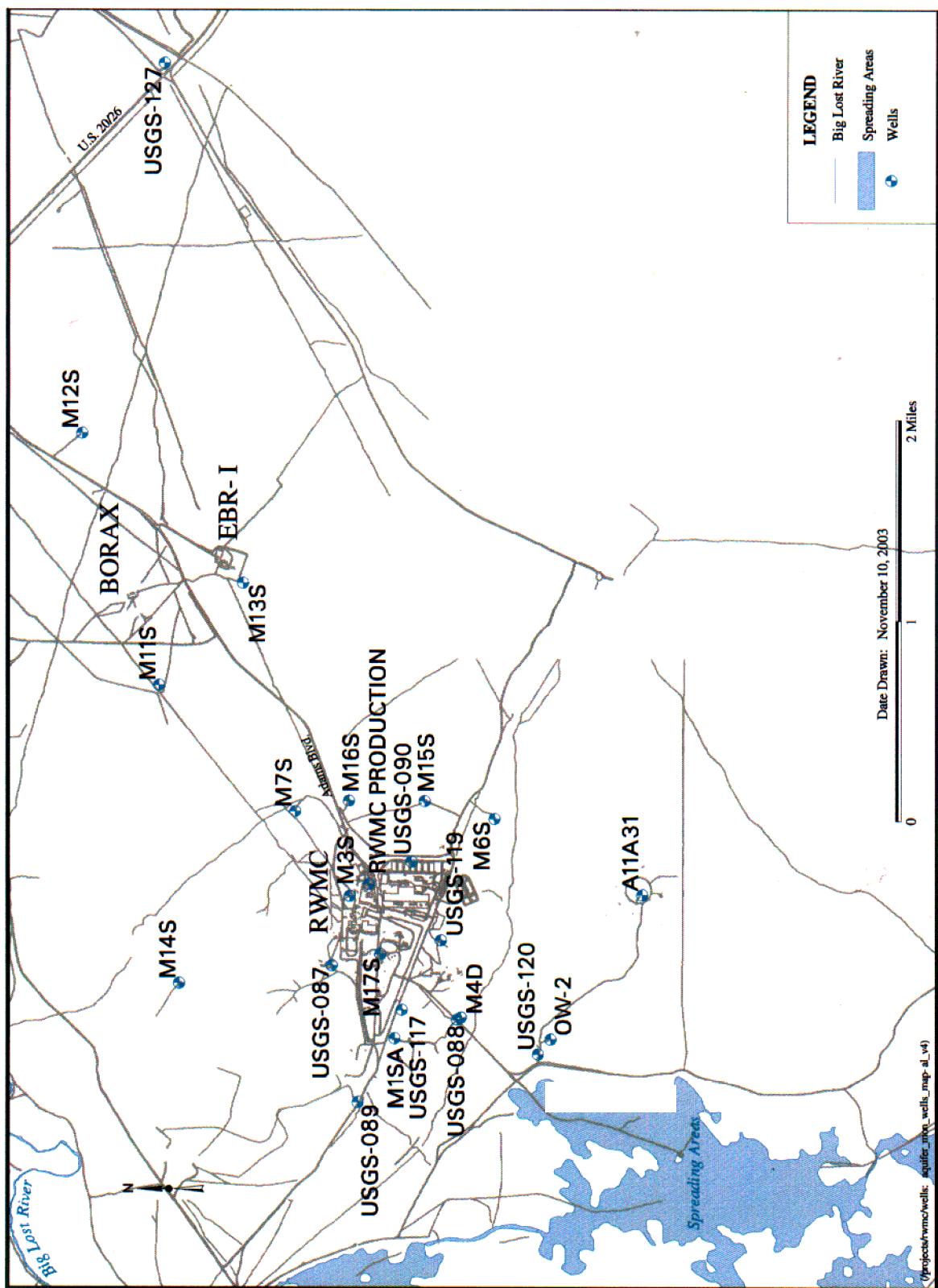


Figure 2-5. Locations of aquifer-monitoring wells at the Radioactive Waste Management Complex.

In an attempt to drill another M10S replacement well, S1898, near the southeast corner of the SDA, the drill bit broke off and lodged into the well. This rendered the well unusable for aquifer monitoring; however, alternatively, three vapor ports, one lysimeter, and one tensiometer were installed to monitor the vadose zone. The vapor ports are installed at three depth ranges: 93–95 ft, 213–216 ft, and 280–283 ft. The suction lysimeter is located at a depth of 223.5–225 ft, and the tensiometer is located at 226 ft.

2.4 Monitoring of Organic Contaminants

Routine monitoring for organic contaminants is conducted at the SDA in the atmosphere, shallow and deep soil gas, vadose zone, perched water, and aquifer. Sample locations and additional details are provided in the discussion of organic contaminant monitoring (see Section 4).

